

## Restoration of Isla Cabritos for the protection of Ricord's Iguana and Rhinoceros Iguana



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## Table of Contents

EXECUTIVE SUMMARY .....	4
 <b>PART A: INTRODUCTION</b>	
Goals .....	5
Objectives of the feasibility plan .....	6
Planning for invasive species removal .....	6
Planning processes .....	7
 <b>PART B: BACKGROUND</b>	
Biodiversity value of Isla Cabritos .....	8
Site description .....	10
Protected status .....	11
Socio-cultural value .....	11
Invasive mammals on Isla Cabritos .....	12
 <b>PART C: DEVELOPMENT OF AN INVASIVE SPECIES REMOVAL STRATEGY</b>	
Support for invasive species removal .....	16
Biodiversity benefit of invasive species removal .....	17
Non-action outcome .....	17
Principles of eradication .....	17
Learning from successful projects .....	18
Recommended strategy to remove burros, cattle, and feral cats from Isla Cabritos .....	19
Technical approach .....	19
Timing of implementation .....	19
Burros and Cattle .....	20
Strategy overview .....	20
Aerial hunting .....	20
Ground hunting .....	21
Methods to confirm eradication .....	21
Duration .....	21
Personnel .....	22
Feral cats .....	22
Strategy overview .....	22
Trapping .....	22
Spotlight hunting .....	23
Detection dogs .....	24

Methods to confirm eradication .....	24
Duration and timeline .....	25
Personnel .....	25
Operational details common across projects	
Island access .....	25
Base camp for operations .....	25
Non-target risk .....	25
Managing tourists during operations .....	26
Unintended consequences of eradication .....	26
Animal welfare considerations .....	27
<b>PART D: BIOSECURITY AND SUSTAINABILITY</b>	
Reinvasion risk .....	28
Monitoring by National Park personnel .....	29
Reintroduction risk .....	29
Community interests .....	30
Ungulate removal .....	30
Social acceptability .....	31
<b>PART E: CONSERVATION MEASURES</b> .....	31
Acknowledgements .....	32
References .....	32

## EXECUTIVE SUMMARY

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Isla Cabritos and Lago Enriquillo National Park is an internationally recognized site important for its unique and abundant biodiversity. Isla Cabritos supports two populations of threatened *Cyclura* rock iguanas, the only viable population of American Crocodile in the Dominican Republic, and the lake supports a diverse array of waterbirds and land birds, including Caribbean Flamingo and West Indian Whistling-duck.

The integrity of Isla Cabritos as a protected area continues to be threatened by the impacts of introduced non-native mammals: feral burros, feral cattle, and feral cats. Burros and cattle cause habitat degradation through over-grazing and trampling, disturb iguana and crocodile nests through digging, and compete for food with iguanas and other native herbivorous species. Feral cats are significant predators of *Cyclura* iguanas, causing high mortality of adults and juveniles, resulting in severe population declines.

The permanent removal of feral burros, cattle, and feral cats has been identified as a priority conservation action to protect the two species of iguana and promote habitat restoration on the island. In this document, we present options and recommendations to eradicate, completely, these three feral mammals from Isla Cabritos. Invasive species eradication is a commonly used conservation tool with which to restore biodiversity threatened by introduced mammals. Invasive species eradication from Isla Cabritos is not technically difficult, and the parameters fall well within the boundaries of other successful projects.

The result of this action will be to safeguard a significant proportion of the critically endangered Ricord's Iguana population, to protect the island population of Rhinoceros Iguana, and to restore habitat for iguanas and other native wildlife on the island.

Community involvement is considered paramount to the long-term sustainability of the project, and to reduce the risk of re-invasion and reintroduction of domestic and feral animals from the surrounding area. Local environmental organizations already working within the area should be engaged to ensure that the conservation gains from invasive species removal are maintained. Ultimately, this conservation management action will improve the integrity of the protected area designations for this nationally and internationally important site.

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## PART A - INTRODUCTION

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Globally, the introduction of non-native herbivores (such as goats, cattle, and burros) has resulted in widespread ecosystem damage through over-grazing, trampling, weed dispersal, prevention of natural succession, and soil erosion, with a subsequent loss of biodiversity. In addition, grazing livestock compete with native herbivores for food resources. As an example, the population decline of the critically endangered Anegada Rock Iguana (*Cyclura pinguis*) in the British Virgin Islands has been in large part due to habitat degradation and food competition with sheep, burros, goats, and cattle that freely graze on the island (Mitchell 1999).

Feral cats have been described as one of the world's worst invasive species (Lowe et al. 2000). They are responsible for a large number of species extinctions, especially on islands where the effects of predation on endemic species are greatest. The extinction of the Stephen's Island wren (New Zealand) in 1894 by the island's lighthouse-keeper's domestic cat is probably one of the earliest cases documented. Feral cats have a particularly damaging effect on ecosystems because they can switch prey to whatever is most abundant at the time (thus able to persist in a range of different habitat types, and impact a range of taxa), and they engage in surplus killing. Feral cat impacts to island bird populations, in particular seabirds, are well-known but there is increasing evidence that cats also impact native and endemic reptile populations. In the Caribbean, feral cats threaten at least four species of *Cyclura* rock iguana, and were responsible for decimating a population of nearly 5,500 adult Turks and Caicos Rock Iguana (*Cyclura carinata*) from Pine Cay in just three years (Iverson 1978).

Isla Cabritos is located within Lago Enriquillo in the western Dominican Republic. The island is home to two species of iguana endemic to Hispaniola: Ricord's Iguana (Critically Endangered, Ottenwalder 1996) and Rhinoceros Iguana (Vulnerable, Day 1996). The lake is also home to the only viable population of American Crocodiles (Vulnerable, Crocodile Specialist Group 1996) within Hispaniola. Three species of invasive mammal present on Isla Cabritos threaten the long-term persistence of the iguana populations through direct predation and habitat degradation: feral burros, cattle, and feral cats, though invasive mice may also be present. Feral ungulates can be removed by hunting while feral cats can be removed primarily by trapping. Permanent removal of these invasive species will benefit the iguana and crocodile populations, and prevent ongoing habitat degradation.

### Goals

- The goal of the project is to protect populations of Ricord's and Rhinoceros Iguana on Isla Cabritos, to restore and maintain the biodiversity integrity of Isla Cabritos, and improve the conservation value of Isla Cabritos and Lago Enriquillo National Park.

## Objectives of the feasibility plan

Invasive species removal from Isla Cabritos has been identified as an important demonstration project, as part of the development of a National Invasive Species Strategy by the Secretaría de Estado de Medio Ambiente y Recursos Naturales, under the CABI/UNEP/GEF collaborative program “*Mitigating the Threats of Invasive Alien Species in the Insular Caribbean*”. The following feasibility assessment evaluates the techniques available for invasive species eradication from Isla Cabritos, and identifies potential constraints to a successful operation. This evaluation was conducted through research, consultation with local biologists, and a brief site visit on October 04, 2010. The implementation of an invasive species eradication campaign would be conducted in partnership with the Subsecretaría de Estado de Áreas Protegidas y Biodiversidad within the Secretaría de Estado de Medio Ambiente y Recursos Naturales.

The objectives of this plan are:

- To present the technical options that could be used to remove feral burros, feral cattle, and feral cats from Isla Cabritos.
- To assist the development and implementation of an invasive mammal removal campaign, through sharing expertise, skills, and knowledge.
- To assist the development of a biosecurity strategy for Isla Cabritos, the aims of which are to prevent natural reinvasion and intentional reintroduction of feral burros, feral cattle, and feral cats, and to maintain the island free of non-native invasive mammals.

## Planning for invasive species removal

A review of successful eradication operations targeting invasive alien vertebrate species on islands reveals several consistent themes, including:

- Public and managerial support and belief in the program’s merit and success.
- Stakeholder consultation and participation.
- Robust and meticulous planning.
- Adequate funding to ensure all stages of the program are undertaken.
- The use of skilled personnel with previous experience in eradication operations.
- Highly motivated personnel with a commitment to the task.
- Personnel experienced and responsive to living and working harmoniously in remote areas for extended periods.
- Flexible approach to resource use to optimize progress.
- Regular analytical reviews of progress and success, and adaptive management in the field.

The basic principles to achieving eradication must be met in every case for all target species:

- All individuals of the target species must be put at risk by the methods used.
- All target species must be removed at a rate faster than they can breed.
- Risk of reinvasion must be able to be managed effectively.
- Methods used are considered humane and ethical.

## Planning processes

A structured planning process will ensure that the technical, logistical, personnel, and financial needs are identified. The project stages outlined below describe a generalized project planning schedule, but are not exclusive of each other. Often, these planning phases will overlap. Identification of funding opportunities should continue throughout the project.

### **Stage 1: Feasibility assessment**

The feasibility assessment (this document) presents the conservation goals of removing invasive mammals from Isla Cabritos, the technical options for removal, the social and cultural considerations, and any potential negative impacts of the project.

### **Stage 2: Environmental assessment, permits, and other regulatory authorizations, draft Operational Plan, draft budget, obtain funding**

Consultation will be required with land owners, land managers, local partners, and Government agencies to determine the legal requirements to implementing an invasive species project. This could include an environmental assessment, risk evaluation for unintentional consequences of the project, identification and application for the relevant authorizations and permits, and ensuring that the project is fully in compliance with local laws and regulations. The Operational Plan will detail the technical approach for eradication, and identify the resources needed to implement. Included in this stage are: GIS mapping and database support, a preliminary budget and identification of funding sources is needed.

### **Stage 3: Operational staging and preparation**

This phase includes contract development, identification and recruitment of personnel, logistical planning, equipment purchasing, establishment of a base camp, staging personnel and equipment.

### **Stage 4: Implementation**

Implementation of eradication is anticipated to take between one and three months for feral cattle and feral burros, depending on the chosen strategy. Eradication of feral cats will take longer, and would occur after feral burro and cattle removal. Implementation includes a post-eradication monitoring phase to confirm complete removal.

### **Stage 5: Post-eradication recovery monitoring**

Pre- and post-eradication surveys of native biodiversity should be undertaken to demonstrate recovery of conservation targets on Isla Cabritos; iguanas are the primary conservation goal. However, monitoring may also include native plant communities and demonstration of habitat recovery. Results from the surveys already conducted by researchers would satisfy the pre-eradication baseline data for iguanas, and compared to post-eradication iguana population estimates using the same survey techniques. Up to three annual post-eradication surveys are recommended.

## PART B - BACKGROUND

### Biodiversity value of Isla Cabritos

Isla Cabritos and Lago Enriquillo wetlands are internationally recognized for their unique and diverse wildlife through several protected area designations. The vast wetlands adjacent to the island and lake shores provide habitat for ibises, egrets, herons, and numerous other shorebirds, including one of the most important sites in Hispaniola for Caribbean flamingos. Some 65 species of land, aquatic, and migratory bird have been reported from the Lago Enriquillo wetlands, including 35 important for the Caribbean region (Anon 2001), six IUCN-listed species, and a small breeding population of Least Tern (Table 1) (Santana et al. 2001).

Common Name	Scientific Name	IUCN	ESA
Ricord's iguana	<i>Cyclura ricordii</i>	CR	
West Indian whistling-duck	<i>Dendrocygna arborea</i>	VU	Species of concern
Hispaniolan amazon	<i>Amazona ventralis</i>	VU	
Rhinoceros iguana	<i>Cyclura cornuta cornuta</i>	VU	
American crocodile	<i>Crocodylus acutus</i>	VU	Endangered
White-necked crow	<i>Corvus leucognaphalus</i>	VU	Endangered
Hispaniolan slider *	<i>Trachemys decorata</i>	VU	
Least paraque	<i>Siphonorhis brewsteri</i>	NT	
Palm crow	<i>Corvus palmarum</i>	NT	
Plain pigeon	<i>Patagioenas inornata</i>	NT	
Least tern	<i>Sterna antillarum</i>	-	Endangered

**Table 1.** Bird and reptile species recorded from Isla Cabritos and Lago Enriquillo and listed by IUCN and the U.S. Endangered Species Act. CR=critically endangered, VU=vulnerable, NT=near threatened. \* Lago Enriquillo is one of only three lakes in which *Trachemys decorata* is found.

Isla Cabritos also has a rich reptile fauna. The island supports two species of iguana endemic to Hispaniola: Ricord's Iguana and Rhinoceros Iguana, which occur sympatrically. Ricord's Iguana is known only from southwestern Hispaniola (Ottenwalder 1996), the Rhinoceros Iguana is more widespread. The lake is also home to Hispaniola's largest population of American Crocodile, and one of the largest anywhere for the species (Perdomo and Arias 2008). A large variety of smaller reptiles, including anoles, snakes, and geckos, also inhabit the island, though no species list was available.



### Ricord's iguana

Ricord's Iguana is one of the most specialized iguanas of the Caribbean *Cyclura* genus, and survives as three subpopulations within the Jaragua-Bahoruco-Enriquillo Biosphere Reserve in southwestern Dominican Republic. In the Neiba Valley the population is restricted to Isla Cabritos and the southern shore of Lago Enriquillo. The species is Critically Endangered (Day 1996) and the subject of a recovery plan by the Iguana Specialist Group (Ottenwalder 1999). The wild population, estimated at between 2,000 and 4,000 individuals, is believed to be declining due to loss of habitat, habitat degradation, and introduced species. In particular, the population along the shore of Lago Enriquillo has suffered from considerable habitat loss as a result of agricultural development, free-ranging livestock, charcoal production, fuelwood extraction, and drainage of wetlands. While the population on Isla Cabritos has benefited from protective management and natural habitat regeneration over the past 15 years, the persistence of feral burros, feral cattle, and feral cats on the island continues to threaten the long-term survival of these animals.



**Figure 1.** Ricord's Iguana, Isla Cabritos, October 2010

Ricord's Iguana populations on Isla Cabritos and the surrounding area have been the subject of several intensive studies, including estimates of population size and habitat preference (Ramer 2004, Rupp et al. 2005, 2007a, 2007b, 2008; Anon. 2008; Dine 2009). Using data from surveys conducted in April 2003 by researchers from the Indianapolis Zoo and Parque Zoológico Nacional (ZooDom), a density of 0.13 iguanas per hectare was estimated (Ramer 2004).

### Rhinoceros iguana

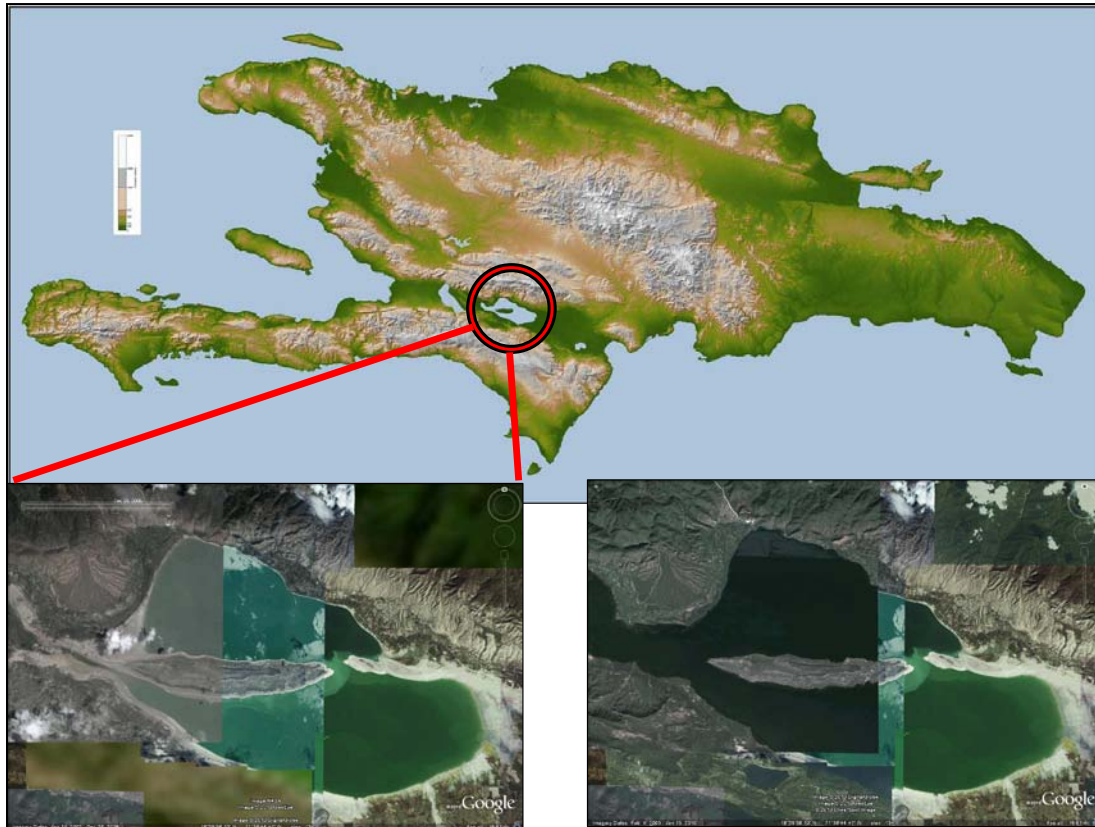
The Rhinoceros Iguana is widely distributed on Hispaniola, including some offshore islands. The species is Vulnerable (Ottenwalder 1996), and current estimates of between 10,000 and 17,000 animals exist in about 20 subpopulations, of which about 10 subpopulations occur in the Dominican Republic. The species range is strongly associated with xeric habitats and low human population density, and in most areas iguanas exist in low densities and appear to be declining due to human pressure (including hunting and trade), and the impact of feral mammals. An estimate of 0.03 iguanas/ha was recorded on Isla Cabritos in April 2003 (Ramer 2004).



**Figure 2.** Rhinoceros Iguana, Lago Enriquillo National Park, October 2010.

## Site description

Isla Cabritos (18°29'N 71°41'W) is an island located in Lago Enriquillo, a hypersaline lake 44 meters below sea level, located at the base of the Bahoruco Mountains, near the western border with Haiti. Isla Cabritos, Islita, and La Barbarita are the only three islands in the lake and in times of drought, are reunited with the mainland through narrow isthmuses of land (Nieto 2007). Isla Cabritos connects to the western shores of the lake, while the two smaller islands connect with the eastern shores (Polanco 2007) (Fig. 3).



**Figure 3.** Topographical map of Hispaniola showing Lago Enriquillo and Isla Cabritos (top), land-bridge formation between Isla Cabritos and the western lake shores in 2003 (bottom left), and the lake water levels in 2010 (bottom right).

Owing to significant water-level rises in the last few years, the current land area of Isla Cabritos is 1,593 ha (data taken from LandSat 7 Satellite, Oct 29, 2010). Previously, the land area has been reported as 2,400 ha (Perdomo and Arias 2008).

The island and surrounding lake are marine or estuarine in origin and once formed part of a larger watercourse linking the bays of Neiba and La Léogâne (Haiti). The island has grown from a sand bar in the 16<sup>th</sup> and 17<sup>th</sup> Centuries to a large island rising 40 meters above the level of the lake. The island substrate is made of coral fragments, limestone sand, mollusk shells, and sandy

clay. There are no bodies of fresh water on the island and introduced mammals dig into the sandy soil, seeking a source of drinking water.

The island is located in what is reputed to be the hottest and driest part of the country. Vegetation is generally classified as dry forest, featuring trees such as *Ziziphus rignoni*, *Prosopis juliflora*, *Guaiacum officinale*, *Acacia macracantha*, and *Bursera simaruba*. Cactus species include *Neoabbottia paniculata*, *Hylocereus undatus*, *Opuntia moniliformes* and *Cylindropuntia caribaea*, *Pilosocereus polygonus*, and *Melocactus lemairei*. Mangrove habitats are comprised almost exclusively of Button Mangrove (*Conocarpus erecta*). Permanent wetlands are dominated by Cattails (*Typha domingensis*), while seasonal wetlands (which experience flooding during periods of heavy rain) are home to halophytic plants including *Batis maritima* and *Sesuvium portulacastrum* (Nieto 2007). A floral inventory of Isla Cabritos recorded 105 species of plant, of which more than 10% are endemic to Hispaniola or the ecoregion. A few exotic plant species have become naturalized on the island, but have not yet become invasive.

There is no infrastructure on the island and the only building houses a small natural history museum. About 2,000 tourists visit per year, but there are no permanent residents. There are a few marked trails which have been established in order to allow visitors to view native iguanas. There is a Park ranger post at the site of embarkation, but no permanent accommodation on the island for wardens or Park personnel (Polanco 2007).

### **Protected status**

Isla Cabritos was declared a National Park in 1974, and extended to incorporate Lago Enriquillo in 1996, which together comprise the Parque Nacional Isla Cabritos y Lago Enriquillo, administered by the Subsecretaría de Áreas Protegidas y Biodiversidad, within the Secretaría de Estado de Medio Ambiente y Recursos Naturales. As an important wetland, the area was designated Hispaniola's first Ramsar site (2002), and more recently was designated an Important Bird Area status (Perdomo and Arias 2008). Lago Enriquillo also comprises one of the core areas of the Jaragua-Bahoruco-Enriquillo Biosphere Reserve, designated in 2002. The National Park comprises about 20,000 ha and is managed by an administrator, a superintendant, three supervisors, 16 rangers, and two boat captains.

### **Socio-cultural value**

Isla Cabritos, Lago Enriquillo, and the surrounding area have historical and archaeological importance. At the time of the arrival of the Spanish, Hispaniola was inhabited by Taíno Indians who had divided the island into five regions called *cacicazgos*; the area around Lago Enriquillo was called Xarajua (Jaragua) *cacicazgos*. The caves and caverns located around the lake were important to the Taínos because they believed that man originated there. They were used as holy places and cemeteries as well as refuges during hurricanes. They decorated the walls of the caves with drawings and petroglyphs with themes alluding to their cultural activities. The best example of Taíno art at the lake is found in a former coral reef called Las Caritas, an archaeological site now visited by tourists.

There has been small-scale fishing at the lake for a long time. Fishing and the availability of fish depend on the degree of salinity of the water and the use of small boats (*chinchorros*). Traditionally, local communities have also harvested crocodiles for meat and fat, and for traditional medicines (Anon, 2001: Ramsar Information Sheet). The feral burros on Isla Cabritos have been harvested periodically (both adult animals and foals), and some of the cattle may be owned or tended by local communities.

### Invasive mammals on Isla Cabritos

A number of invasive mammals have been reported from Isla Cabritos, including mice (*Mus musculus*), feral burros (*Equus asinus*), feral cattle (*Bos taurus*), feral cats (*Felis catus*), feral goats (*Capra hircus*), and horses (*Equus caballus*). It is suspected that some or all of these animals originally came to the island during a dry period when the waters of Lago Enriquillo receded and a land bridge gave animals access to the island (Polanco 2007). As the land-bridge forms every 15-30 years, repeated invasions occur. In the past, some species of livestock were also intentionally brought to the island. In April, June, and September 2003, when water levels were low and the land-bridge existed, feral cattle, burros, horses, and feral cats were reported during iguana surveys, with herds of up to 12 horses recorded in April (Ramer 2004). However, recent reports have only included burros, cattle, feral cats, and mice (Polanco 2007, C. Rijo and N. García pers. comm.).

### Feral burros

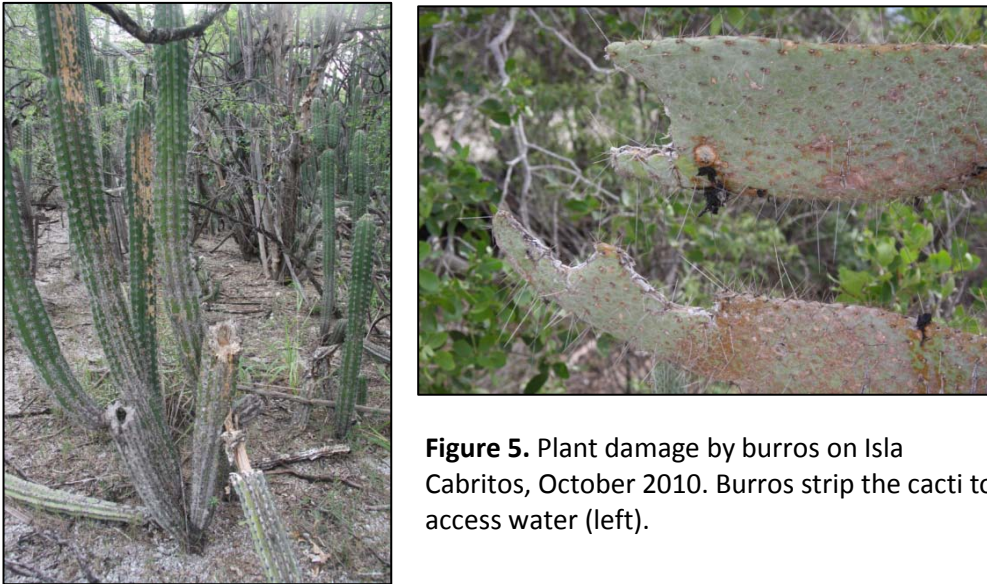
Feral burros are large herbivores which can have profound effects on island ecosystems. They have been reported as a non-native feral species in at least 16 different countries, including the Turks & Caicos Islands, British Virgin Islands, and the Cayman Islands in the Caribbean. Impacts from burros have been documented on plant communities, soils, wildlife, and water quality; they cause erosion and vegetation damage through trampling, introduce and disperse weeds through their dung, and compete for food and water with native species. In the Galapagos Islands, burros have severely disturbed the native flora and are thought to have caused the extinction of one plant species endemic to the islands (Carrion et al. 2007, Fortwangler 2009). Of particular concern is the competition for forage. In the Mojave Desert (USA), burros compete for food with the threatened Desert Tortoise (*Gopherus agassizii*). In the Cayman Islands, Anegada Island (British Virgin Islands), and the Turks and Caicos Islands they impose a serious threat to the endemic and endangered rock iguanas (*Cyclura* sp.) through food competition, alteration of vegetation composition, and by trampling soft substrates where iguanas burrow or nest (ISSG database). In the Galapagos Islands, feral burros trampled Land Iguana (*Conolophus subcristatus*) nests, and damaged



**Figure 4.** Feral burro, Isla Cabritos, October 2010



between 12% and 32% of giant tortoise (*Geochelone* sp.) nests (Neira and Roe 1984). Overgrazing of vegetation may also increase the temperature of substrates, and this is suspected of impacting reptiles elsewhere in which sex is determined by incubation temperature of eggs. A lack of vegetation also facilitates predation of young iguanas by native and non-native predators (Dowling 1964). It is likely that burros and cattle are having similar impacts on nesting crocodile and iguana populations on Isla Cabritos. Burros, like cattle, have been reported digging in the soil on Isla Cabritos, presumably to find water (Polanco 2007). This observation was supported by biologists from the Ministry of Environment and Natural Resources during a field site visit in October 2010.



**Figure 5.** Plant damage by burros on Isla Cabritos, October 2010. Burros strip the cacti to access water (left).

The number of burros on Isla Cabritos has not been formally counted, but an approximate estimate of about 100 animals was proposed by local biologists, which seemed reasonable given the abundant animal sign (tracks, fresh and old scat) that was seen. On an afternoon visit on October 04, 2010, a total of 10 burros were seen (mostly individuals) within 2 kms of the visitor centre, including one animal with a medium-sized foal. On a previous visit, up to 30 animals were seen within 1.5 kms east of the visitor center (N. García pers. comm.). Two different pelage colors were noted, a dark chocolate brown (Fig. 4) and a sandy-beige. Animals encountered could not be approached closer than about 30 m.

While the impact of burros on vegetation on Isla Cabritos has not been formally studied, evidence of browsing was observed on several different plant species (Fig. 5). A dense network of trails caused by burros and cattle can clearly be seen on Google Earth images throughout the entire island, and aerial photographs during the site visit in October 2010 demonstrated similar impacts. The combined effects of trampling and grazing by burros and cattle is also likely to have contributed to the open, sparse vegetation cover on the island (Fig. 6).



**Figure 6.** (Left) Feral burro and cattle tracks; (Right) south shoreline of Isla Cabritos, the large areas of sandy bare ground are probably caused by burros and cattle. Burro tracks can also be seen along the water's edge.

### Feral cattle

The origin of the cattle on Isla Cabritos is unknown. Some animals are probably entirely feral, while others may have owners who may occasionally tend them. According to Polanco (2007), many cattle owners are known to the Park rangers. Polanco (2007) also described evidence that livestock on Isla Cabritos dig in the ground to find freshwater, disturbing the soil and in the process damaging iguana and crocodile nests.

Feral cattle severely modify native habitats by trampling and browsing, causing erosion, habitat destruction, and soil degradation. In native forest, they can eliminate nearly all the young trees resulting in an open and bare forest floor. In Hawaii, they have been regarded as the single most destructive agent to Hawaiian ecosystems, in particular to the native koa forests (Baldwin & Fagerlund 1943). On Anegada Island (British Virgin Islands) and the Turks and Caicos Islands, they impact the endangered rock iguanas (*Cyclura* sp.) through food competition, habitat alteration, and trampling of nests and burrows. In southeastern Arizona (USA), the presence of feral cattle was linked to decreases in reptile abundance and higher predation rates on reptiles, as a result of desertification caused by overgrazing (Castellano and Valone 2006).



**Figure 7.** Fresh sign of feral cattle on Isla Cabritos, October 2010.

The numbers of feral cattle on Isla Cabritos is not documented. During a field site visit in October 2010, few animal signs (scat, tracks) were observed suggesting relatively low densities (especially in comparison to sign of feral burros). However, both old and fresh sign (Fig. 7) was observed indicating that the cattle are still present on the island.

## Feral cats

Effects of predation on native species by feral cats are widespread, particularly on islands (Whittaker 1998). Cats depredate a wide range of species, including mammals, birds, reptiles, amphibians, and insects (Nogales et al. 2004). They impact ecosystems by causing extinctions and extirpations, or reducing species to population levels at which they no longer perform functional ecosystem roles. Because of these impacts cats are considered among the most damaging introduced mammals and are included in 100 case studies of the world's worst invasive species (Lowe et al. 2000).

Feral cats are responsible for the extinction of at least 33 bird species globally (Lever 1985). Even small numbers of cats can have dramatic impacts as evidenced by their effect on the Stephen's Island wren (*Traversii lyalli*; New Zealand) which was driven to extinction by one or more cats in 1894 (Fuller 2001). On the islands around the Baja California Mexico peninsula, cats have been responsible in part or wholly for the extinction of 11 mammal and 10 bird species, and the extirpation of 22 bird populations (Wolf 2002, Keitt et al. 2005). Feral cats are documented to have enormous impacts on insular seabird colonies, where, with abundant food, they can achieve large populations with high densities of animals. Researchers have estimated cat induced seabird mortality for Marion Island (450,000 seabirds annually, (Bester et al. 2002)), Macquarie Island (47,000 Antarctic Prions (*Pachyptila vittata*) and 110,000 White-headed Petrels (*Pterodroma lessonii*) annually, (Jones 1977)), and Kerguelen Island (1.2 million seabirds annually (Pascal 1980 cited by Nogales et al. 2004)).

In addition to seabirds, the diet of feral cats on islands is largely made up of small mammals and reptiles (Biro et al. 2005, Harper 2005). However, cat diet changes with food availability and cats are known to take the most abundant food source at any one time (Veitch 1985, Bester et al. 2002). The dietary adaptability of cats increases their impact on island ecosystems by enabling them to maintain relatively high populations throughout the year even if a major food source is present for only part of the year (Courchamp et al. 1999).

Feral cats are known to be one of the most significant threats to endangered rock iguanas (*Cyclura* sp.) in the Caribbean where they prey upon juvenile animals, sometimes reducing recruitment rates to near zero levels. Predation of adult and young iguanas has been documented for the Lesser Antillean Iguana (*Iguana delicatissima*) in Anguilla, the critically endangered Anegada Rock Iguana (*Cyclura pinguis*) in the British Virgin Islands, and the critically endangered Ground Iguana (*Cyclura lewisi*), and Lesser Iguana (*Cyclura nubile caymanensis*) in the Cayman islands. In the Bahamas, feral cats (together with feral dogs) were credited with



**Figure 8.** A feral cat consuming a juvenile Galapagos marine iguana.



decimating a population of more than 5,000 adult Turks and Caicos Rock Iguana (*Cyclura carinata*) from Pine Cay in just three years (Iverson 1978). In 1995, iguanas were found on only five of 26 of the Turks and Caicos islands where cats or livestock were present (Ottenwalder 1999).

The number of feral cats on Isla Cabritos has not been determined. During an afternoon visit on October 04, 2010, one cat was seen at 15:35hrs near the shoreline in the northwest of the island. Two sets of fresh cat prints (Fig. 9) were found about 43ft and 250ft east of the cat sighting. While there may be areas of higher cat densities, it is likely that cats are dispersed across the entire island.



**Figure 9.** Fresh cat tracks on Isla Cabritos, October 04, 2010

## PART C – DEVELOPMENT OF AN INVASIVE SPECIES REMOVAL STRATEGY

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### Support for invasive species removal

The goal of the proposed strategy to permanently remove feral burros, feral cattle, and feral cats from Isla Cabritos is to promote native habitat restoration on Isla Cabritos, and to protect native and endemic biodiversity, specifically Ricord's Iguana, Rhinoceros Iguana, and American Crocodile. Eradication of these invasive species from the island is the primary means of achieving this goal.

Invasive species eradication from Isla Cabritos has already been identified as a critical management action, and is supported by several initiatives, including:

- The National Invasive Alien Species Strategy currently being developed identifies invasive species removal from Isla Cabritos as an important pilot project with which to increase the local capacity to manage invasive species impacts on biodiversity in the Dominican Republic.
- The West Indian Iguanas: IUCN Status Survey and Conservation Action Plan (Alberts 1999) identifies feral cat eradication from Isla Cabritos as a priority action to protect Ricord's Iguana.
- Isla Cabritos and Lago Enriquillo is a National Park, is one of the core zones of the Jaragua-Bahoruco-Enriquillo Biosphere Reserve, is a designated Ramsar site, and an IBA, important for large numbers of waterbirds, including flamingos, egrets, herons, ibises, shorebirds, and the West Indian Whistling-duck. Invasive species removal from Isla Cabritos improves the biodiversity value of these protected areas and the strength of these designations.



- The National Biodiversity Strategy recognizes the impact of invasive animal species on local biodiversity, in particular the impact of predation on endemic and native species with small populations, and recognizes that invasive species have impacted the national system of protected areas (Ministerio de Medio Ambiente y Recursos Naturales, 2010).
- The IUCN Crocodile Specialist Group recognizes the significance of the Lago Enriquillo population of American Crocodile as the largest in Hispaniola, and that the only other population on Lake Étang Saumâtre in Haiti has become significantly reduced since the 1980s (Ross 1998).

### **Biodiversity benefit of invasive species removal**

Invasive species removal from Isla Cabritos will specifically benefit three endangered reptiles. Feral cat removal will eliminate predation of young iguanas and thereby increase recruitment rates, and feral ungulate removal will eliminate damage to iguana and crocodile nests and burrows, remove food competition between ungulates and iguanas, and restore habitat thus increasing food and habitat availability for iguanas. Feral cat removal will also benefit nesting birds, such as the small colony of Least Terns, and other reptile species on the island. Habitat restoration through feral ungulate removal will also benefit the unique plant communities on the island, and improve habitat quality for reptiles and birds. Overall, removal of invasive species will strengthen the value of the region's IBA, National Park, Ramsar, and Biosphere Reserve status.

### **Non-action outcome**

If these invasive mammals are not removed from Isla Cabritos, the impacts described for the two endangered iguanas and the island's habitat will persist. Over time, this will result in increasing habitat degradation and threat to the long-term persistence of iguanas on the island. Significantly, without the threat of invasive mammals, the Ricord's Iguana population on Isla Cabritos could be the only fully protected population on the island of Hispaniola. Given that Ricord's Iguana is currently threatened in most of its mainland range by habitat loss and degradation from charcoal burning, mortality from feral cats, dogs, and mongoose, and poaching, the Isla Cabritos population could contribute significantly to the long-term persistence of this species on Hispaniola. In addition, this project will increase awareness of invasive species issues, and the value of Isla Cabritos, and biosecurity activities and increased vigilance implemented as part of this project will also help to prevent the introduction of other invasive species to Cabritos (such as goats, dogs, horses) which could occur if no action is taken.

### **Principles of eradication**

The basic principles to achieving successful eradication of an invasive mammal are:

- All individuals of the target species must be put at risk by the methods used.
- All target species must be killed at a rate faster than they can breed.
- Risk of reinvasion must be zero or able to be managed effectively.

In addition, the methods used should be humane and ethical, and comply with the relevant local regulations. Multiple techniques are often needed, and rarely can one technique alone (with the exception of some rat eradications) achieve eradication. In addition, different techniques are often needed to remove the last few animals and to confirm that eradication is complete.

### **Learning from successful projects**

Feral ungulate eradication has been used frequently as a conservation management tool to promote island restoration, including removal of feral goats, feral burros, cattle, and various invasive deer. The techniques therefore have been refined and shown to be effective in the field. Feral goats have been the most common species targeted, and have been eradicated from at least 130 islands worldwide (Campbell and Donlan 2005). The largest successful eradications include: 80,000 goats from Santiago Island (53,465 ha) and 41,682 goats from Pinta Island (5,940 ha) (both in the Galapagos Islands) (Campbell and Donlan 2005, Cruz et al 2009), and 26,266 goats from San Clemente Island (14,800 ha) in the United States.

Feral burros have been eradicated from at least seven islands: in Mexico from San Benito West (350 ha), Coronado South (227 ha), Guadalupe Island (26,470 ha), and Todos Santos North (62 ha); from San Miguel Island (3,865 ha) in California; and from Santiago Island (58,465 ha) and Alcedo Volcano (74,103 ha) in the Galapagos. Eradications of feral cattle have been less extensive, but reports of removal in the Galapagos Islands from Santa Cruz in the 1980s, Floreana in 2008, and from Enderby Island (sub-Antarctic) in the 1990s are documented.

The most common method of removal has been hunting, both ground and aerial operations from a helicopter. Hunting may include the use of hunting/detection dogs and Judas animals. Removal of live animals has been documented for only nine (out of 120) feral goat eradications indicating that it has not been the preferred option. On small islands, such as Isla Cabritos, a single technique could be used to achieve eradication.

Similarly, feral cat eradication for conservation purposes is a commonly used management tool, and at least 87 feral cat eradications have been completed worldwide (Nogales et al. 2004, Campbell et al. in press, Island Conservation database). Island size is one of the factors that determines the difficulty of an eradication, and the majority of cat eradications (65%) have occurred on islands smaller than 400 ha, while 24% (21/87) have been larger than 1,000 ha (Campbell et al. in press). The most frequent techniques used are trapping and hunting. Direct poisoning and secondary poisoning techniques have also been used; the most common toxicant used for direct poisoning has been sodium monofluoroacetate (1080), used in 17/19 campaigns. In the majority of cat eradications, a combination of techniques has been used. Typically, use of toxicants and biological controls tend to be most effective at the beginning of an eradication operation, whereas hunting and especially trapping are often the only effective techniques to eradicate the last few remaining individuals.

The removal of feral ungulates and feral cats has, therefore, been used frequently as a tool for conservation purposes, and at 1,593 ha, Isla Cabritos is well within the size range for successful eradication.

## Recommended strategy to remove burros, cattle, and feral cats from Isla Cabritos

In 2003, feral burros, cattle, goats and horses were all reported from Isla Cabritos, but recent information suggests that only feral burros and cattle remain. Further consultation is recommended with the National Park rangers and community members to confirm that burros and cattle are the only feral ungulates to currently exist on the island. If horses and feral goats are still present, the eradication strategy presented below would need to be reviewed.

### Technical approach

It is recommended that feral burros, cattle, and cats be removed completely and permanently from the island. A two-step eradication approach is recommended. Burros and cattle should be removed first as they will interfere with traps set for feral cats. It would be beneficial to remove feral cats as soon as possible after the ungulate eradication because of the possibility of a significant vegetation re-growth resulting from the release from suppression by ungulate grazing. An increase in vegetation cover would make cat detection and access throughout the island more difficult. Cats should be primarily trapped and, where necessary, hunting methods will be used to remove the last few individuals.

The beginning stages of an eradication operation will see the greater number of animals removed in a very short time, when rapid progress can be made. Typically, about 90% or 95% of animals will be removed within the first third of the operational time, the remaining 5% or 10% of animals will be removed in the second third of the operation, and the remaining third will be spent searching for the last one or two animals and confirming eradication. Often, the reasons for an eradication failure is because insufficient effort is spent searching for the last few animals and the project is declared complete too early when a few animals still remain.

### Timing of implementation

Ideally, eradications take place when target animals are at low densities, are non-reproductive, or experience large die-offs. If a bait or other-food based lure is used, eradication when animals are food-stressed can also be more efficient. This period typically occurs during the dry season, when food availability is at its lowest. In addition, many plants on Isla Cabritos lose their leaves during the dry season, which would increase the visibility of both feral ungulates and cats, improving trapping and hunting efficiency. García et al. (1978) show that the months of lowest rainfall in the westernmost extremes of the Dominican Republic, including the Neiba Valley, occur December through February, with the months of January and February each receiving less than 50 mm of rain. Operations should also be planned to occur well outside of the iguana breeding season to reduce any physical disturbance to animals. The reproductive period for these animals is largely dictated by rainfall (Weiwandt 1977 in Vogel (1994)). In Ricord's Iguana, oviposition occurs in May and June, after the first (short) rainy period and juveniles hatch September and October, in alignment with the second rainy season (Ottenwalder 1996). In Rhinoceros Iguana, oviposition usually occurs over a two-week period from late July to early August (Weiwandt 1977 in Vogel (1994)). It is therefore recommended that operations be

implemented between December and April, coinciding with much of the dry season and prior to the hurricane season.

## Burros and cattle

### Strategy overview

- Live burros and/or cattle removed by the local community before operations.
- Aerial hunting (recommended)
  - deploy skilled professional hunters and experienced pilot.
- Ground hunting
  - zone delineation.
  - initial population reduction with professional hunters.
- Ground monitoring to detect any remaining animals.
- Repeated ground monitoring 3 (aerial), 6 and 12 (ground) months post-eradication to confirm complete removal.

Due to their similar feeding habits and large size, both of these species can be removed using nearly identical techniques. It is estimated there are about 100 feral burros on the island, and less than 10 cattle (N. García pers. comm.). Any animals that are owned by the local communities should be removed before the eradication operation (see *Community Interests*). Due to the significant safety risk from firearm use, no-one who is not part of the operation (including tourists, local visitors, Park wardens, etc.) should be allowed access to the island during hunting operations. Animals can be hunted away from areas frequently visited by tourists so that they are not exposed to carcasses.

We have presented below two options for burro and cattle removal: aerial hunting and ground-based hunting. While aerial hunting using a helicopter could appear to be very costly, previous removal projects have demonstrated that it can be the more cost-efficient approach due to the time efficiency of the technique compared to ground-hunting. However, an aerial hunting operation requires highly skilled personnel, and a helicopter and pilot that are authorized to operate in the Dominican Republic. If a suitable helicopter and pilot are not available locally, then the delays in getting the appropriate authorizations and permits to import both could reduce the practicality of choosing this option. In addition, an aerial hunting operation does not allow for local community involvement, which is important for long-term sustainability of the project. These considerations should be evaluated when deciding the most appropriate technique to use.

### Aerial hunting

Aerial hunting is the preferred method for removing burros and cattle from Isla Cabritos. It is a cost effective and efficient method of removing ungulates from islands, even in countries where labor is inexpensive (Carrion et al. 2007, Cruz et al. 2009). Efficiency of aerial hunting operations depends on an experienced pilot who has performed the same type of work before, use of a preferred model of helicopter (e.g. McDonnell Douglas 500D/E series), experienced

marksmen, and the use of preferred firearms. Aerial hunting has proven effective at removing feral burros, especially in areas with open canopy; their large size and inherent lack of hiding behavior makes them highly vulnerable (Carrion et al. 2007). Cattle are equally easy to hunt in the same conditions.

### **Ground hunting**

As Isla Cabritos is fairly flat, and most if not all areas are accessible on foot, a ground hunting operation is also possible but would take significantly more effort, time, personnel, and possibly cost, in comparison with an aerial hunting operation. Various specialized hunting strategies have been used successfully on other island eradications such as; a form of team line hunting called *rastrillo*, free hunting, and strategic spot hunting (Cruz et al. 2009) The success of a ground hunting operation will depend on the use of extremely skilled and motivated hunters with expertise and experience in eradication work. There is the potential to train and utilize local hunters and/or the Park rangers in the skills needed for the ground hunting operation for burros and cattle. The hunting strategy would require division of the island into manageable zones, with hunting implemented systematically in each zone by teams of between two and three hunters, to avoid animals going undetected. The size of each zone will depend on the estimated time it will take hunters to effectively cover the ground. All hunters should record their movements across the island with a GPS unit. In addition, any relevant operational data should be collected including animal sightings, animals removed, animal sex/age, GPS location etc.: These data will allow for real-time monitoring of progress, and provide information needed to make adaptive management decisions (Lavoie et al. 2007).

### **Methods to confirm eradication**

After the completion of an aerial hunting operation, at least one ground visit will be necessary to confirm eradication. The confirmation survey would consist of an island-wide search for fresh sign (e.g. scat, prints). After completion of a ground hunting operation, the confirmation phase would begin at the point at which animals are no longer being detected on the ground. Local Park rangers and tour guides could be trained to monitor the island for any sign of remaining animals. It is important that any sign detected is photographed, details of the sign are recorded (e.g. type and age of sign, time of day), and a GPS location is obtained.

Use of camera traps for cats (see section on *Feral cats, methods used to confirm eradication*) could simultaneously act as a detection/confirmation tool for the ungulate species.

### **Duration**

Some large herbivore eradication projects have taken many years, even decades, but in many cases it was because the short term goal was to control and not eradicate populations of feral animals (Jouventin et al. 2003, Carrion et al. 2007). With the development of new technology and expertise, complete eradication of feral ungulates from very large islands is now more feasible. The length of implementation of the eradication operation will depend on the method used.

An aerial hunting operation would likely require between about six and ten hours of aerial hunting time, with additional time needed for helicopter refueling, etc.:. This could be achieved in two or three days. Follow-up confirmation would occur three months after the eradication, requiring two ground hunters for about one week.

A ground hunting operation could take between several weeks and up to about three months to complete. Follow-up confirmation would occur six and 12 months post-eradication.

### **Personnel**

An aerial hunting operation would require two skilled and experienced precision marksmen, an experienced helicopter pilot, and a support crew for the helicopter (e.g. mechanic, fuel loader etc:).

A ground hunting operation would require between six and eight skilled and experienced hunters. Two ground hunters would be required for follow-up eradication confirmation for both aerial and ground hunting operations.

## **Feral cats**

### **Strategy overview**

- Island-wide survey to record locations of fresh cat sign and activity.
- Zone delineation, trap and camera trap placement.
- Trap monitoring & revisiting trapped areas for sign of fresh activity.
- Intensive monitoring if individuals persist.
- Monitoring at 6 and 12 months with camera traps, sign searches, and other tools.
- Confirmation of eradication.

The recommended option to remove feral cats from Isla Cabritos is through a combination of traps and hunting, including hunting at night with spotlights and possible use of detection dogs. A successful cat eradication on Isla Cabritos will employ both of these methods. While toxicants have been used elsewhere to eradicate feral cats (combined with traps and hunting), we would not recommend it as a primary eradication technique for Isla Cabritos because of the potential mortality to iguanas, and because currently the most common toxicant used for cats (sodium monofluoroacetate) is not registered for use in the Dominican Republic. Even with trapping, mitigation measures need to be taken to ensure minimal impact to non-target species, especially for the two species of iguana.

### **Trapping**

Intensive trapping would need to take place over the course of several months, depending on the number of individuals that are on the island. Effective trapping for cats can include use of live leg-hold traps (Victor soft catch), live box, or cage traps (Tomahawk™). Skilled trappers should be engaged to prevent animals from becoming trap shy. It may be possible to employ

local workers if they are properly trained and supervised. Lethal traps are not recommended for use on this island because of the risk of injuring or killing iguanas.

Due to the presence of the iguanas, which could be injured by leg-hold traps, mitigation measures will need to be taken in order to minimize any impact. Such methods may include: only setting traps at locations where there is cat sign to reduce the number of open traps, and only opening traps at night when iguanas are inactive; cats are primarily nocturnal so traps open during the night would target cats during peak activity. Another possible mitigation method is to set leg-hold traps on the top of 50 liter buckets filled with sand, so that the bait, lure, and trap is off the ground. Ratcliffe et al. (2009) have shown that cats will jump up onto similar trap sets. In addition, a mobile veterinary unit could be deployed on Isla Cabritos during operations to provide evaluation and supportive treatment for any injured iguanas. Veterinary officers from the Parc Zoológico Nacional (ZooDom) could fulfill this function well, and any animals that might be permanently debilitated could be relocated to the Zoo for breeding purposes.

Traps will be baited with an attractant and placed in areas of activity, as indicated by cat sign (e.g. scat, tracks). Possible attractants may include fresh meat, commercial cat food, commercial (e.g. catnip oil (*Nepeta cataria*)) or home-made olfactory lures (including a mixture of scat, urine, scent gland extraction, glycerine), or audio lures. Traps should be set in the evenings and checked in the mornings, before the day gets too hot (reducing the chance of heat stress to a trapped animal). Any traps left open or set during the daytime should be preferably placed away from the regular tourist route. Searches for cat sign across the entire island will be required, but trapping can be localized to areas where cat sign is found and at points that are suspected to be critical travel routes. A skilled trapper will be able to anticipate areas of high cat activity based on a cat's micro-habitat preferences and typical trail-routes, and thus increase trapping efficiency. Trapped animals would be removed from traps promptly and dispatched on site using the appropriate techniques.

A trap monitoring system developed for feral cat eradication from San Nicolas island (California) could be used to increase trap-checking efficiency (Hanson et al. 2010). The system comprises transmitter units connected to traps, an island-wide radio-repeater system, and a GIS database with field PDA data collection. When activated, a transmitter sends a radio signal indicating that the trap is operational; the signal changes once a trap is sprung. Repeaters relay trap status data to a dedicated computer which captures location information from a GIS database, allowing field staff to quickly identify which traps are sprung and plan the most efficient route between traps. This system also reduces the risk to non-target animals as the response time to checking traps is very short, and an animal can be released very quickly.

### **Spotlight hunting**

Hunting for cats is most effective at night, using spotlights. Cats have a distinctive 'eye shine' when seen in a spotlight. Although lights can be uncomfortable for an animal to stare at, an experienced hunter can operate one effectively, both identifying and removing an animal before they can learn to avoid looking at the lights. A competent marksman experienced in spotlighting is required to reduce the frequency with which animals effectively avoid detection



or removal by this method. When the location, or home range, of an animal is known, hunting with the aid of a spotlight and an appropriate firearm (e.g. .223 or similarly caliber rifle, 12 gauge shotgun) at night can be effective in removing potentially trap/bait shy individuals.

### **Detection dogs**

Hunting aided by specially bred and trained detection dogs can greatly increase the efficacy of traditional hunting, especially when the target species is wary of other methods and/or are at low densities. The aid of dogs is especially useful when densities are low because of the dogs keen sense of smell and ability to follow scents over large distances in a relatively short amount of time. Dogs are able to detect individuals from wind-borne or ground scents and track them to their resting places or dens, enabling their removal by hunters. There is a possibility that hunting dogs could cause disturbance to iguanas, but well-trained dogs which remain on the island only for the duration of the eradication campaign should only cause a brief and minimal disturbance; on the Galapagos islands, detection dogs were trained to avoid Land Iguanas (*Conolophus subcristatus*) and Marine Iguanas (*Amblyrhynchus cristatus*).

### **Methods to confirm eradication**

One of the most important and often most overlooked portion of an eradication operation is eradication confirmation, and the detection methods used to achieve this (Campbell et al. in press).

Detection methods for cats can include the use of camera traps (including use of an olfactory or audio lure to attract cats), looking for sign on the ground (e.g. scat, paw prints), traps, and the use of detection dogs. Once cats can be no longer detected on island, the operation can move into the monitoring phase. The Isla Cabritos National Park rangers could play a significant role in monitoring and detection efforts by searching for sign. It is important that any sign detected is photographed, details of the sign are recorded (e.g. type and age of sign, time of day), and a GPS location is obtained.

All activities during the eradication operation should be recorded, for example GPS data for traps, date of capture, age and sex of animal, unintended mortality, unintended escapes, etc.:. These data provide managers with an updated progress of the eradication operation, as well as assisting in making critical adaptive management decisions (Lavoie et al. 2007). The use of a probability of detection model based on data collected during the eradication can be used to estimate the number of animals that may persist, as well as the amount of continued surveillance required to declare the eradication complete (Ramsey et al. in press). Such surveillance would include the use of camera traps in conjunction with searches for sign. Without application of this detection model, additional confirmation visits to the island would be necessary to confirm eradication, probably for six months, one year, and two years after the last few animals were removed. These confirmation trips would consist of a focused, island wide search effort and could serve as dual purpose to confirm eradication of both cats and ungulates.



## **Duration and timeline**

The cat eradication operation would take place after feral ungulates have been removed from the island to prevent these large animals from interfering with traps, and to allow sign to be clearly interpreted. An initial period of intensive trapping would last from a few weeks and up to 12 weeks, or until animals become wary of traps. Once a noticeable decrease in the number of trapped animals occurs, the operation would move into a hunting phase, with spotlight hunting at night, and hunting with detection dogs. Assuming that feral cats are distributed across the entire island, time to complete eradication on Isla Cabritos could be between four and six months, with further follow-up monitoring needed to confirm eradication.

## **Personnel**

During the initial trapping phase, up to six trappers would be needed to set and check traps daily. Once the population has been substantially reduced, between two and four skilled trappers/hunters would be needed to remove the remaining individuals. If detection dogs are used, an experienced dog handler would be responsible for working with and taking care of dogs.

## **Operational details common across projects**

### **Island access**

Isla Cabritos is easily accessed from the National Park ranger station at La Azufrada located less than two miles east of the town of La Descubierta. This is also the access site for tourists visiting the island. The National Park staff manages a number of small boats that provide access to the island. The boat crossing to the pier adjacent to the visitor center is less than five miles and takes about 25 minutes. Support from the National Park staff would be needed to access the island.

### **Base camp for operations**

Operations would be primarily based out of the town of La Descubierta. Given the ease of access to the island, there is no need to base personnel on the island for the long-term. This will also reduce the environmental impact and human footprint from the operation. La Descubierta has a hotel and small stores sufficient to support a small field team. Alternatively, a house and/or storage building could be rented as an operations base in La Descubierta. For some operations, for example hunting or trapping feral cats at night, a small overnight camp may be required on the island, and some on-island storage will be needed for traps and other equipment and supplies.

### **Non-target risk**

During the removal efforts, there will always be a risk of accidental injury or mortality to an individual of a native species on Isla Cabritos. Of most concern are the two iguana species because of their threatened status and because they are larger animals. We anticipate that the biggest risk would be accidental injury from cat traps. While mitigation efforts to reduce this risk would be in place (see section on *Trapping Feral Cats*), some injury or mortality could still

occur. Other risks might include temporary physical disturbance to native animals from helicopter or ground operations.

### **Managing tourists during operations**

For any operation that involves hunting and firearm use, the island would have to be closed to the public for the duration of the activity. Information on the number of visitors to the island on a daily or seasonal basis would be useful when planning the operations. Ideally, the campaign would take place at a time when there are few visitors, but ultimately the operation would be conducted at the time of year when the chances of eradication success are maximized.

During trapping operations for feral cats, most traps can be placed away from the main tourist areas. Tourists are usually accompanied by a Park ranger, along the main trail (the Iguana trail) which runs for about 1 mile southeast of the visitor center. However, during the final phase of the feral cat eradication, traps need to be placed where cat sign is found which might include the tourist areas. Rangers should be briefed on the eradication operations and conservation goals of the project so that they can educate their visitors appropriately.

Disposition of burro and cattle carcasses will also need to be away from the main tourist area so as not to disturb visitors. Final disposition of carcasses would need to be discussed with partners and the local community, but options could include leaving them in-situ, or dragging or airlifting with a helicopter to the shoreline (where crocodiles could dispose of them). Animals would be hunted primarily away from the tourist areas, but any carcasses that might remain visible to tourists would need to be removed. Some freshly killed animals could also be made available to the local community for meat.

### **Unintended consequences of eradication**

The removal of large herbivores from Isla Cabritos will eliminate habitat degradation from over-grazing, provide more food for iguanas and herbivorous/frugivorous birds, and allow vegetation communities to recover. While this will be beneficial for native plants, there is also the possibility that some non-native plant species may appear and out-compete some of the native species - although herbivore removal will also eliminate weed seed dispersal by cattle and burros that no doubt currently occurs. Micol and Jouventin (1995) documented an initial increase in the abundance of introduced flora after the control of cattle on Enderby Island in the sub-Antarctic, though native flora continued to increase in abundance several years after the control efforts. As part of the planning process, consultation with local biologists would be needed to identify non-native plants present on Isla Cabritos that could become invasive with reduced grazing pressure, and an action plan should be developed for any species that is highlighted as potentially invasive.

The removal of feral cats from the island might result in an irruption of mice. The theory of trophic cascades and ecological release of a prey species as a result of the removal of a predator or competitor, has been well studied (Courchamp et al. 1999, Zavaleta 2002, Caut et al. 2007, 2009) and several examples exist (e.g. cats/rabbits on Macquarie Island (Bergstrom et al. 1999), rats/mice in the USVI (Witmer et al. 2007)). While we do not know of a specific case

that documented an irruption of mice following cat eradication, Rayner et al. (2007) reported a decrease in seabird nest success due to increased predation by Pacific rats (*Rattus exulans*) after removal of feral cats. Following cat eradication, it is conceivable that mouse populations will increase, with associated impacts. However, given the known significant impact of feral cats on iguana populations, feral cat eradication is imperative. We recommend that monitoring is conducted to establish baseline abundance of mice, and any potential increase in mouse abundance and/or an increase in mouse impacts should be developed as a proactive measure prior to the proposed cat eradication.

### **Animal welfare considerations**

All methods used in eradication attempts must meet strict animal welfare standards. While there is no international standard for these regulations, widely accepted guidelines include the American Veterinary Medical Association guidelines for euthanasia, best management practices for trapping from the International Association of Fish and Wildlife Agencies, and the Australian humane pest animal control codes of practice and standard operating procedures (Sharp and Saunders 2005a, b, IAFWA 2006, AVMA 2007). These documents provide guidelines and set standards for vertebrate pest control and eradications. The methods proposed for use in this project plan meet the requirements outlined in one or more of these documents.

Frequently, citizens concerned about animal welfare recommend live capture and relocation, or neutering the animals and releasing them at the place of capture. This practice is often called trap-neuter-release (TNR) or trap-neuter-abandon, and is particularly relevant to feral cats (Jessup 2004). TNR is not a viable method for eradicating invasive vertebrates from islands except in very rare situations. Most TNR advocates recommend releasing the animals at the site of capture. This is not an option in eradication programs because the presence of the trapped and neutered animals will make it exceedingly difficult to detect and trap the remaining individuals. Potentially all animals could be held until the entire population is caught. However, because the captured animals are wild, it is arguably less humane to hold the animals in captivity than to humanely kill them soon after capture. Furthermore, if the animals were released after all were neutered, the damage caused by these animals would continue until they died naturally, which is at odds with the restoration goal of the project. Another alternative proposed has been the capture, neuter, and transfer of animals to a mainland site away from the island. This is unacceptable in most situations because it is often illegal to abandon feral animals on the mainland where they will also cause environmental damage. Furthermore, the transport of live animals off the island is likely to cause significant stress in a wild animal and be contrary to animal ethics standards.

## PART D - BIOSECURITY & SUSTAINABILITY

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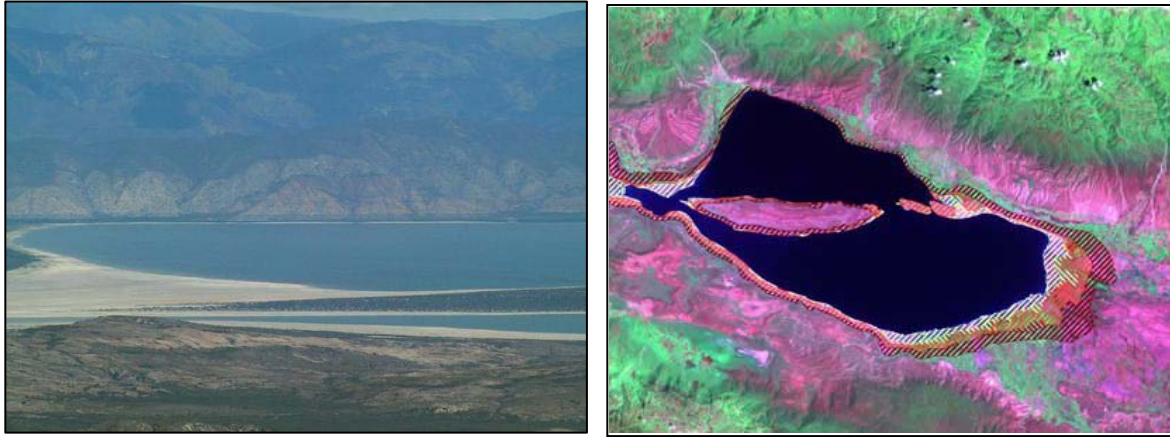
The long-term benefits of invasive species removal to the biodiversity of Isla Cabritos will depend on support from local communities and maintaining the island free of invasive and domestic animals. While management of the National Park has contributed significantly to the recovery of the two iguana species on Isla Cabritos, created a livelihood for local community members, and generally encouraged awareness in local communities about the island's value, the full benefits to the Park from invasive species removal will not be realized if burros, cattle, and feral cats either naturally reinvade or are intentionally reintroduced to the island.

### **Reinvasion risk**

The biggest obstacle to maintaining Isla Cabritos free of non-native animals is the re-occurrence of the land-bridge that forms periodically between the island and the western shores of the lake (see Figures 1 and 10), allowing animals to re-populate the island.

Lago Enriquillo undergoes extreme fluctuations in water levels during periods of drought, high evaporation, and heavy rainfall (in particular hurricanes). Exactly how frequently this has occurred in an historical context is not documented, but is generally considered to be about every 15-30 years (Ottenwalder 1999). The 1979-1980 cycle resulted in lake water levels rising more than 3 m. High water levels were also apparent in September 1993, demonstrated by a NASA satellite image where the land-bridge was absent. In March 1997, following a two-year period of drought and reduced rainfall, the island had again become connected to the mainland (Ottenwalder 1999). However, beginning February 2000, water levels increasingly rose as a result of frequent hurricanes. A land-bridge existed in April, June, and September 2003 (Ramer 2004) but by February 26, 2009 the lake had increased in size by 27 sq. miles compared to its 2000 area. NASA images show that no land bridge was apparent in August 2007 and January 2008. In 2008, Hispaniola was subjected to the worst hurricane season in recent memory receiving five tropical cyclones, and as of October 2010 the water levels were still very high.

We can expect, therefore, for Isla Cabritos to be present as an island for extended periods of years, but for a land-bridge to be also present for up to several years. In order for natural re-invasion of burros and cattle to occur, the animals have to be free-ranging in the adjacent countryside. Most burros and cattle would likely be owned by the local community, and it is less likely that feral populations of these animals would be ranging the shores of Lago Enriquillo. For this reason, the likelihood of domestic burros and cattle re-populating the island independently, without the owners knowledge, is low. However, the likelihood of feral cats reinvading the island via a land-bridge is much higher as there are probably feral cat populations on the adjacent lakeshore.



**Figure 10.** Lago Enriquillo water levels. (*Left*) Lago Enriquillo land-bridge on the western shores (unknown date); (*Right*) the extent of flooding in November 2007 (white), January 2008 (yellow), July 2008 (orange), and January 2009 (red). The smaller islands Islita and Barbarita can also be seen adjacent to the eastern shores of the lake. CATHALAC/SERVIR.

### **Monitoring by National Park personnel**

Isla Cabritos and Lago Enriquillo both comprise the core of several protected areas, each with their own laws and regulations governing their use and management. In particular, the National Park is equipped with rangers and tour guides who visit the island frequently. The rangers would need to be taught to search for, recognize, and document the sign of burros, cattle, feral cats, and other non-native species such as goats, horses, and feral pigs that could invade the island across a land-bridge. A reporting and response system would need to be created, so that any animals arriving on the island can be quickly removed. Because the lake water levels recede over periods of one or two years, there would be plenty of time to prepare a search and response program, including training rangers in trapping and/or firearm use.

### **Reintroduction risk**

In order to prevent the intentional reintroduction of domestic animals to the island, a community outreach program should be conducted in the surrounding towns and villages to educate people on the ecological and economic (through eco-tourism) value of Isla Cabritos, and discourage individuals from bringing animals to the island.

While some of this work could be done by the National Park, it is proposed that a partnership with an organization that has a wider reach among a larger community be developed. Grupo Jaragua work within the Jaragua-Bahoruco-Enriquillo Biosphere Reserve, of which Isla Cabritos is a part, and implement community outreach and environmental education programs for a number of projects within the region. As Birdlife's country representative, they participated in the designation of Lago Enriquillo Important Bird Area, and manage a number of bird conservation programs. In addition, their role in ongoing research and recovery activities for Ricord's iguana as part of the IUCN Iguana Specialist Group makes them well-placed in both

location and expertise to develop and assist with this project, in particular with community participation and ensuring the long-term biosecurity and sustainability of the project.

## Community interests

### Ungulate removal

During the site visit in October 2010, members of the community at La Descubierta expressed an interest in obtaining live burros prior to eradication. In the past, it seemed that at least four or five young foals, and one adult female, had been removed for domestication (although the adult female reportedly escaped and returned to the island). The local community regards the Isla Cabritos burros as having better genes than their domestic animals and thus good to breed from.

Removal of live adult animals is not recommended as an eradication technique (see below). In addition, any removal of live animals owned by the local community should occur several months before a ground-based hunting operation, because capture of live animals could increase the animals' wariness and make a ground-hunting operation more difficult.

The original proposal to eradicate the burros suggested capturing live animals by baiting them with water and food placed inside a fenced area, and removing them by boat to the mainland. While this might provide the local community with animals for breeding, it is not recommended as an eradication technique for reasons of animal welfare, poor cost-efficiency, and low probability of success. About 100 burros are estimated to be on the island. It is considered unlikely that every animal could be attracted into a fenced area; some animals will remain very wild and likely hide in the most densely vegetated part of the island. In addition, either several fenced areas would need to be constructed throughout the island, or all animals would need to be attracted to one centralized fenced area, a minimum distance of about 3.5 miles from each end of the island. Once captured, animals would need to be anaesthetized by a veterinary officer in order to be removed by boat. To reduce the time that animals are held in captivity, and so reduce stress, anaesthetizing animals for removal would preferably take place as soon as possible after capture. This would necessitate the continued presence of a veterinary officer during the capture effort. Once an animal is anaesthetized, it would need to be kept cool and monitored continually for signs of physiological distress or recovery from anaesthesia. Each animal would need to be carried to a boat for removal. This would require five or six men to lift each animal; domestic adult donkeys can weigh up to 258 kgs (570 lbs), and it is likely that these wild burros weigh heavier. Should an animal begin to recover from anaesthesia while on the boat, this could create an extremely dangerous situation. Once on the mainland, each animal would need to be transported to a new location, and monitored until full recovery from anaesthesia.

If removal of some live animals is considered an important measure to secure community and partner support for the project, further consultation with these stakeholders is recommended to understand the community's needs and develop a solution.



### **Social acceptability**

Isla Cabritos and its biodiversity is a valuable natural resource to the people of the Dominican Republic, and the iguana and crocodile populations are a valuable economic resource to the local community as an attraction for local and international tourists. Between 1989–1999 (not including 1990, 1992 and 1995), there were a total of 22,949 visitors. This represents important income that contributed to the administration of the area. For the period 1994–1999 (not including the year 1995) income in the amount of DR\$ 419,294 was reported (Anon 2001: Ramsar Information Sheet). As there is no permanent human habitation on the island, and cats provide no intrinsic benefit (aesthetically, ecologically, or as “mouse-catchers”), it is unlikely that the removal of cats would be contested by the local communities. However, removing livestock from the island might be more disputed. Rangers interviewed by Polanco (2007) did not seem to be aware of the importance of preventing cattle (no mention of burros) on the island, nor understand the impacts that these animals were having upon the flora, fauna, and landscape. If this is still true, it is unlikely that eradication of burros and cattle will win community support without first engaging local people, and implementing a public awareness campaign prior to eradication operations. This is especially true if some or all of the animals are owned by local people. Local support for the project is imperative to ensure that biosecurity is maintained, and guarantee long-term sustainability of the project.

## **PART E - CONSERVATION MEASURES**

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The ultimate goal of removing invasive species from Isla Cabritos is to protect the island’s biodiversity and facilitate habitat recovery. In order to demonstrate that this goal has been achieved, we recommend implementing pre- and post-eradication biological monitoring of native species as a before and after comparison. One or more components of the Isla Cabritos ecosystem can be selected for monitoring, for example a single species, vegetation cover, or plant community composition. Monitoring the Ricord’s Iguana population would likely demonstrate recovery post-cat eradication, while monitoring total vegetation cover, plant community composition, or seedling regeneration would likely demonstrate the effectiveness of feral ungulate removal. At least one survey prior to eradication to establish baseline information would be needed. For iguanas, this information might already be available from surveys conducted by Grupo Jaragua and Indianapolis Zoo from 2003-09 (Ramer 2004, Rupp et al. 2007, 2008, Anon 2008, Dine 2009). Given the known impact of feral cats on juvenile iguanas, a particular focus on juvenile iguana survival and annual recruitment rates may be a better indicator of recovery than a total population estimate. Information on vegetation cover can be obtained from satellite or other digital aerial images, and may also already exist through J. Dine’s research (Dine 2009). To document recovery, at least one post-eradication survey is recommended. Recovery rates of iguanas may be very quick and change may be detected within one or two years post-eradication, but changes in total vegetation cover (able to be detected with aerial images) may take longer and a survey four or five years post-eradication is recommended. Vegetation recovery could also be monitored using seedling recruitment rates.

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